Math and the Parthenon

Middle School Lesson Plan

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Goal:

Students will learn how different types of math are incorporated into the architecture and look of the ancient parthenon

Objectives:

As a result of this lesson, students will:

- learn what optical refinements are and how they make the parthenon appear to be "perfect"
- determine ratios and dimensions of the parthenon
- explore how math concepts used by the greeks are still used in the western world today
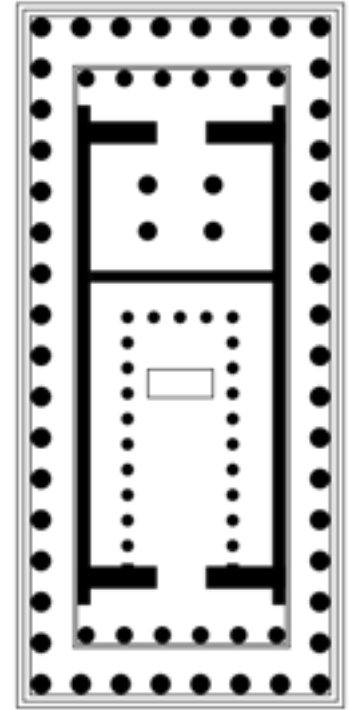
HISTORY:

In order to understand the math involved, a brief history of the Parthenon is needed.

The Parthenon was completed in 432 BC, as a temple to Greek Goddess Athena, Goddess of war and wisdom, and also patron saint of Athens. It stands high on the Acropolis, symbolizing power and influence. Under the command of head of State Pericles, sculptor and mastermind Phidias, and architects Ictinus and Callicrates were hired for the job of building. They did an impeccable job, as for today, during restoration, we can see that piecing together the parts is nearly impossible, like a perfect puzzle.

Dimensions

- The base of the Parthenon is 228 feet long by 101 feet wide

- The base area is 23,028 square feet

- There are 46 columns: eight in the front and back and 17 on each side (corners counted twice)

- Each column stands approximately 34 feet high

- Athena stands 41 feet 10 1/2 inches tall, with Nike at 6 feet 4 inches

- The ceiling is 45 feet high

This is an aerial view of the base and columns in the parthenon.

Let's think about this...

That means the Parthenon is about half the size of a football field in area!

You would need 132 5 foot students lying down in a row to circle all the way around the base!
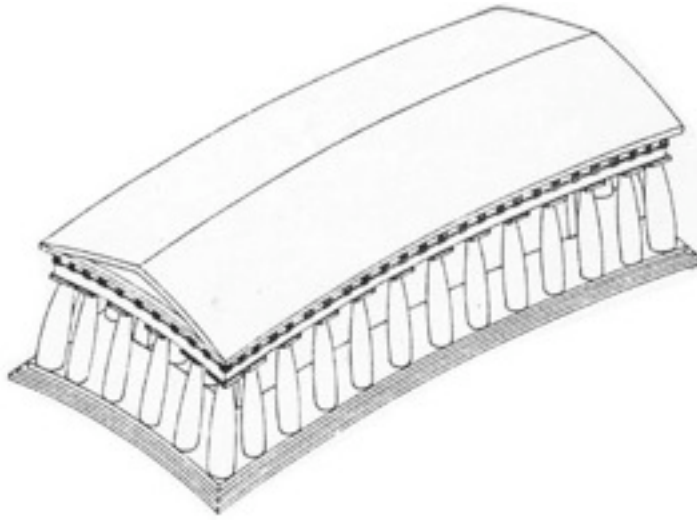
To touch the ceiling you would need nine 5 foot students to stand on top of each other!

Even though Nike looks so small, she is taller than most of you!

You would need eight 5 foot students to touch Athena's crown!

Optical Refinement

Activity:

Start with showing students this short video from NOVA on optical refinements in the Parthenon.

http://www.youtube.com/watch?v=vzhA3yiEofI

Now use this link, and have students do some of the illusions. Talk about it and ask who saw what.

http://www.scientificpsychic.com/graphics/

Secrets:

As you can see from the video, visual perfection is the goal in including illusions in building. Of course, to be able to do this exactly right, math comes into play.

all of the "straight" lines on the Parthenon are not actually geometrically straight. A series of "optical refinements" were purposefully built into its structure.

Long straight floors tend to "dip" in the middle. To counteract this, the center of the base of the Parthenon was raised by four inches on along the sides, and two inches along the front.

MORE SECRETS...

COLUMNS TEND TO LOOK NARROWER IN THE MIDDLE, SO EACH COLUMN IN THE PARTHENON WAS BUILT WITH A SLIGHT BULGE IN THE MIDDLE, TO MAKE THEM APPEAR "STRAIGHT." THIS IS CALLED ENTASIS.

COLUMNS TEND TO "CONTRACT" TOWARDS THE TOP, SO THE BASE OF EACH COLUMN WAS BUILT A LITTLE THICKER.

THE COLUMNS WERE SPACED WIDER APART, TO AVOID LOOKING SMALLER TOWARDS THE CENTER.

THE CENTER COLUMNS WERE BUILT THICKER, BECAUSE FROM FAR AWAY THE OUTER COLUMNS CAN LOOK BIGGER.

THE COLUMNS WERE BUILT SLANTING SLIGHTLY INWARD, SO THEY WOULD MEET IF EXTENDED EXACTLY ONE MILE INTO THE SKY.

THIS IS CORRECTED WITH THE TRIANGULAR ROOF, MAKING THE TOP PART OF THE COLUMNS APPEAR TO SLANT OUTWARD.

LONG, STRAIGHT LINES APPEAR FROM A DISTANCE TO "DIP" IN THE MIDDLE. TO COUNTERACT THIS, ALL HORIZONTAL LINES IN THE PARTHENON, SUCH AS THE FLOOR OR CEILING CURVE UPWARD TOWARD THE CENTER OF THE BUILDING ON A 9" CURVE.

Diagram 1
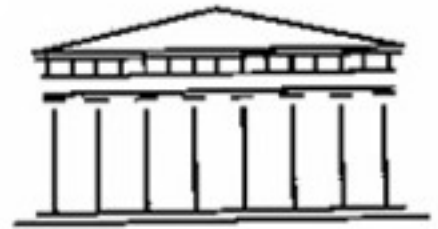The temple as it visually appears with correction

Diagram 2
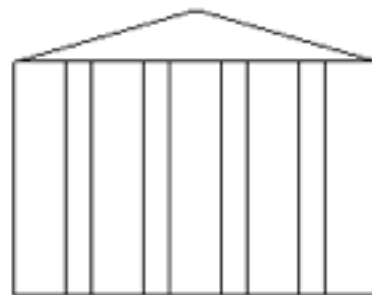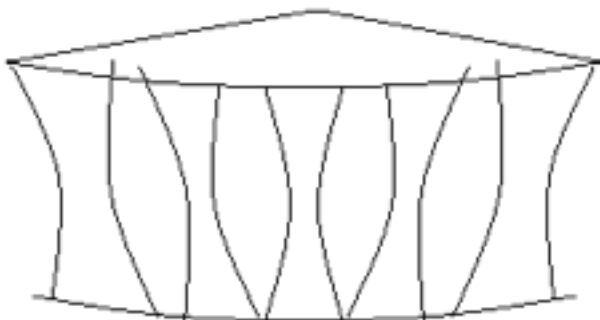The temple as it would appear without correction

Diagram 3
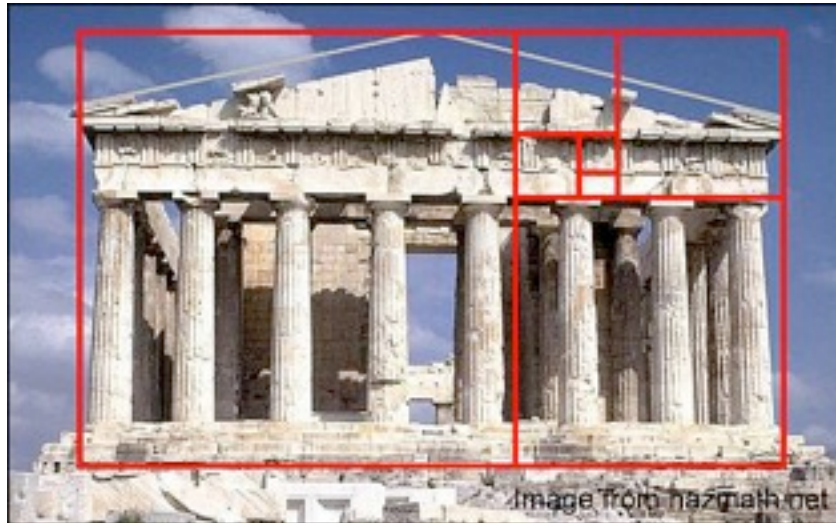The temple as it is actually built with Correction

Optical Correction (Entasis) In Doric Temples

THE FIGURES AT THE SIDE AND BOTTOM, SHOW EXAGGERATED VERSIONS OF THE ILLUSIONS, AND THEN WHAT YOU SEE WHEN YOU LOOK AT IT, A PERFECT FORM.

ACTIVITY:

PUT THE ILLUSION PARAGRAPHS ON THE BOARD, AND HAVE STUDENTS DRAW WHAT THEY THINK THE EXAGGERATED VERSION LOOKS LIKE. THEN PUT UP WHAT THEY ACTUALLY LOOK LIKE. THIS IS TO SEE IF STUDENTS CAN VISUALIZE WHAT THE GREEKS DID.

Golden Ratio

according to greeks, a golden ratio is a rectangle with ratio from length to width being 1.61803 39887 49894 84820. This ratio has long been considered most pleasing to the eye. This shows that they used math in the very blueprints of parthenon. This figure outlines golden ratios in the parthenon.

A ratio of 4:9 is also found throughout the Parthenon. You can find it between the width of the columns and the distance between Their centers, and the height of the facade to its width.

This google earth image shows overlapping circles in which the 4:9 ratio could be derived from a vesica. The larger circles have a radius of half a stadium long.

Extra Credit

Theoni Pappas, author of The Joy of Mathematics, will present a free lecture at the Nashville Parthenon, Tuesday October 7, 2009 at 7:00 PM. Have students go to the lecture, and write a one page summary to turn in the next day on the topic for extra credit points.

Conclusion Activity

Have students do the crossword puzzle at this link:

http://www.variety-games.com/CW/Puzzles/148973729-puzzle.htm

This should test their knowledge on the subject matter, as well as be a fun activity. Alone or working in groups is okay.

Resources

THese are links to many pages I found useful in the planning of this lesson, as well as other information on the Parthenon.

http://www.math.nus.edu.sg/aslaksen/projects/perspective/parthenon.htm

http://www.geom.uiuc.edu/~demo5337/s97b/art.htm

http://www.nytimes.com/2008/01/29/arts/television/29genz.html

http://www.pbs.org/wgbh/nova/parthenon/program.html

http://en.wikipedia.org/wiki/Parthenon

http://www.ancient-greece.org/architecture/parthenon.html

http://www.greatbuildings.com/buildings/The_Parthenon.html

http://www.michaelbach.de/ot/